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A MANAGEMENT ANALYSIS AND STRUCTURAL MODEL OF THE DEFENSE ACQUISITION SYSTEM

By

Gregg M. Burgess
Florida State University
Tallahassee, FL 32306-1042

Thomas D. Clark, Jr.
Florida State University
Tallahassee, FL 32306-1042
(904) 644-5508

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INTRODUCTION

Since the 1950's there has been a nearly continuous call for far-reaching reforms in the way that the United States' defense establishment develops, produces and contracts for major weapon systems (Coulam 1977, Stubbing 1986). The basis for this pressure to reform comes from the public's perception of wasteful defense spending, the rapidly rising costs of the weapons which are procured, and a shrinking share of the GNP being allocated to defense, due mainly to an unwillingness to fund larger defense budgets at the expense of expanding social programs (Weida and Gertcher 1987). Contributing to the public's perception that the defense industrial complex is unable to efficiently manage defense resources are the well publicized instances of spare parts overpricing, weapon program cost overruns and delays, and the operational deficiencies of some of the weapon systems which are procured.

To illustrate the failings of the defense-industrial complex with any specific weapon purchase admittedly is debatable. Proponents and opponents of the system have often grossly exaggerated their defense or condemnation of the system. There does seem to be, however, a consensus that the weapons could be procured at a lower cost and delivered in a more timely manner. Even though there is a continuing debate about the causes for the ever increasing costs and production delays, there is consistency in assigning blame. Basically there are three groups which blame each other and are blamed by others for the inefficiencies in defense weapons acquisition. These are the defense industry, the Department of Defense and the armed services, and the Congress.

Individual firms within the defense industries have been blamed for exacting unreasonable profits and have been widely accused of fraud (Kotz 1988). The Department of Defense has been accused of bureaucratic inefficiency and pursuing wasteful practices as a matter of policy (Fitzgerald 1972). When considering defense issues, the Congress is maligned as a purveyor of "pork-barrel" politics and widely accused of inefficient micromanagement (Kotz 1988, Stubbing 1986).

The disparity in opinions about what causes system behavior and the debate about blame indicate that no general understanding about the system's true structure has developed from the wide attention given it. One of the two key objectives of the research reported in this paper, therefore, was to develop a systemic-framework model which was useful in describing the system's component variables and detailing their interrelationships. The second objective was to use the model to understand the behavior of the system that results from its inherent structure. As the research progressed, it was clear that the thirty or so senior executives and scholars who were interviewed about the structure and behavior of the system did indeed have a wide diversity of opinion about the structure of the system and the causes of its behavior. They also shared a concensus that a systemic approach to management must be taken to reduce costs and shorten delivery time. An overview of the interviewee population is shown in Table 1.

Place Table 1 About Here

The research process, the development of the model, and the description of system structure and behavior will be focused upon in the remainder of the paper. Specifically, the model will be used to address the questions of how Congressional, Department of Defense and industry structures

Table 1. Interview Respondent Structure

	Congress	Executive Branch DOD	Executive Branch Other	Industry	Academic/ Analytical
Strategic	2	11	1	3	
Operational		3	4	3	
Analyst/ Staff	2	4		1	5

and policies impact the cost and delivery of the weapons which are procured. A framework for policy development also will be discussed.

Most scholars and executives agree that there are three key processes which determine the behavior of the acquisition system. The three processes are: the determination of weapon requirements, the design of specific weapon systems based upon those requirements and the regulatory process. The requirements process determines the kinds of weapons which are to be built as well as the capabilities of individual weapon systems based on an analysis of the future threat and an estimate of expected friendly forces.

The design process is the link between the requirements and production phase during which individual weapon systems are developed based on stated requirements. The regulatory process determines the legal environment in which the acquisition of weapon systems takes place between the Department of Defense and the defense industry.

These three processes are represented in the structural model which is presented here. The processes are represented by the interaction of the following variables, which have been consistently identified in the literature and interviews: production technology used, the number of weapons produced, the length of production time, the weapon technology, and the development period (Clark, Whittenberg and Woodruff 1986, Coulam 1977, Fallows 1981, Fox 1974, Gansler 1980, Stubbing 1986). Each of these factors are impacted in some way by the structures and policies which are pursued by the defense industry, the Congress and the Department of Defense. These factors also are influenced by the threats to our national security, as well as the organizations which play a role in the weapons procurement process. These four elements, the DoD Congress, industry and national threat, form the basis for the subsystems that become the major focus in the paper.

BACKGROUND AND FOCUS

The underlying reasons behind the tendency to procure increasingly expensive weapons stem from the change in the strategy which the United States used for developing weapons after the Second World War. During World War II, the United States produced relatively low technology weapons in vast quantities, technological advances tended to be incremental and the weapons were prototyped and tested prior to production (Coulam 1977). Since the War, the United States has sought to overcome, with technologically advanced systems, the numerical advantage in weaponry which potential adversaries have had.

The result has been production of weapons which are significantly more expensive in real terms and which take much longer to develop and produce (Gansler 1980). For example, in constant dollars, the 1960 F-4 fighter aircraft cost $3.5 million while the 1975 F-15 aircraft cost more than $12 million. A similar comparison of the World War II vintage British Spitfire aircraft with its modern day replacement, the Tornado, shows a remarkable 17,200% increase adjusted for inflation (Dyer 1985). The result of the rapid rise in both the cost and technology of modern weapons is that no nation, not even the richest, is able to afford to equip mass armies with modern weapons in the old style (Dyer 1985).

The rapid advances in technology has created weapons with extraordinary lethality. Since, the combination of extremely lethal and extremely expensive weapons results in smaller numbers of weapons available for combat, any future engagements will necessarily be short because neither side will be able to produce enough weapons to keep up with losses (Brooks 1983, Dyer 1985). For example, in 1973, the Israelis and their opponents lost about fifty percent of

their equipment in less than three weeks of combat (Dyer 1985). Coventional war has evolved into what is essentially a "come as you are" affair, which will not allow the U.S. to utilize its industrial capacity (Brooks 1983, Dyer 1985). This puts a premium on military readiness.

This significant change in the way that the United States develops its weapons has been mirrored by the Soviet Union, and even by some less developed countries. All countries seek to buy the best weapons available (Dyer 1985). Within the United States, this behavior has been reinforced by the interaction between the defense industry and its customers, the armed services. The defense industry has obvious reasons for wanting continuously to produce new and better weapons to replace existing ones. That is how the industry is able to maintain its highly technical workforce, which seems to stress weapon design over production, and, after all, is the way profits are generated. The individual services also have incentives to procure these weapons as they compete amongst themselves for a share of the national security role and the resources that go with it (Luttwak 1984, Fallows 1981, Dyer 1985). The defense industry is also able to exert considerable political pressure at times to achieve its desired ends (Stubbing 1986). The services are able to reinforce the political pressure by focusing attention on the developing threats to national security (Dyer 1985). The services' behavior is reinforced by a system which encourages officers to defend their own service's interests in acquiring new weapons, defining roles for them, and managing the enormous amounts of resources necessary (Luttwak 1984, Dyer 1985).

The net result is that United States weapon acquisition policy has changed from large buys of low cost, low technology weapons to small buys of

high cost, high technology, highly lethal weapons which require long development periods and long production times (Brooks 1983).

In some respects, the trend is self magnifying, because any weapons procured in smaller quantities will cost more when industry overhead costs are spread over a smaller production run (Coulam 1977, Perry 1979). The rapid increase in weapon technology and weapon costs has not coincided with real increases in defense spending, which tended to be flat through the 1950's, 1960's and 1970's (Fallows 1981, Gansler 1980). As long as acquisition funding stays at a nearly constant level and the United States continues buying the same number of increasingly expensive weapons, longer and cheaper production runs will be impossible due to fiscal constraints.

One hope for breaking this cycle of spiraling weapons costs is that production efficiencies would enable the U.S. to produce the weapons more cheaply and high technology components would become less expensive as they have, for example, in consumer electronics (Gansler 1980). This has not occurred, largely due to the impact of the ever increasing sophistication of weapons technology that has been designed into the weapons produced. Weapons design continually has been pushed to the leading edge of technology (Gansler 1980). Production efficiencies depend, to a great degree, on the learning curve phenomena, large production runs, and relatively stable product and production technologies (Gansler 1980). To some degree the learning curve phenomena has been taken advantage of, although the effects have been mitigated by the shorter production runs and design instability in many production runs (Coulam 1977, Gansler 1980).

A second factor, that offsets any efficiency increases from technology improvements in the weapons is the defense manufacturers' historical dependence on government provided plants and equipment, especially in the

aerospace industry (Gansler 1980). As a result, production is not accomplished using state of the art methods, but often using older and less efficient plants and equipment (Coulam 1977, Gansler 1980).

The ever-increasing cost of weapons and a near constant acquisition budget will probably result in much less efficient production of weapons as a higher percentage of costs reflect development and production overhead rather than variable production costs and added value. The result is that the United States may not be able to maintain, with a shrinking share of GNP, the credible deterrent to threats to its national security that it has for the last forty years. Norman Augustine, the current president of Martin Marietta Aerospace, has calculated that at the current cost growth and expenditure rates, only one military aircraft could be purchased with the whole defense budget in the year 2054 (Augustine 1986). If this trend continues, systemic pressures certainly will force changes in acquisition policies. In fact the "nearly continuous" calls for reform alluded to earlier have been attempts at finding the steps required to improve the performance of the defense acquisition system. It is not necessarily that the system of weapon acquisition inherently is flawed but rather that as the fiscal constraints get tighter, changes will be required for the system to function efficiently.

The history of studies dealing with the topic of weapon acquisition reform is quite long and includes works such as The Weapons Acquisition Process: An Economic Analysis (Peck and Scherer 1962), Arming America: How the U.S. Buys Weapons (Fox 1974), Illusions of Choice (Coulam 1977), The Defense Industry (Gansler 1980), National Defense (Fallows 1981), and The President's Blue Ribbon Commission on Defense Management (1986). In general, these studies have in one way or another considered the external military threat to our national security, national priorities, defense priorities, the

defense acquisition bureaucracy, national political forces, the national policy making bodies, and the defense industry that produces the weapons. Two of the predominant paradigms for conducting the studies have been first, use of economic theories (Fox 1974, Gansler 1980, Peck and Scherer 1962) and second, use of the less analytical, more intuitive, experienced-based approach of the various commissions (President 1970, President 1986) and others (Fallows 1981, Fitzgerald 1972, Luttwak 1985, Stubbing 1986).

These studies support the conclusion that basic reform of the acquisition system has not been accomplished although it is not for a lack of effort. In the 1950's concurrency of production and development was implemented to reduce the time of weapons development and to forego the expense of prototying (Coulam 1977, Stubbing 1986). The current problems of the B-1B bomber procurement show the difficulty of managing concurrent acquisition with highly sophisticated weapons. In the 1960's Secretary of Defense Robert McNamara tried to implement joint purchases for perceived common requirements. Navy and Air Force purchase of the F-4, A-7 and F-111 aircraft are examples. Extensive modification of these aircraft to serve particular needs of each service made this an expensive strategy.

Secretary McNamara also introduced total package procurement contracts to reduce cost growth, introduced a centralized decision making and budgeting process (PPBS), and created a strong systems anlaysis group within the Department of Defense (Clark, Wittenberg and Woodruff 1986, Stubbing 1986). Total package procurement contracts have created significant problems for some manufacturers with the near bankruptcy of Lockheed perhaps the best example.

In the 1970's, Deputy Secretary of Defense David Packard implemented the Defense System Acquisition Review Council (DSARC) process which reduced concurrency pressures and reliance on fixed price contracts, and decentralized

the responsibility and authority for acquisition management (Clark, Whittenberg and Woodruff 1986, Stubbing 1986). In the 1980's, beginning with the "Carlucci initiatives" and continuing with the proposed implementation of many of the Packard Commission's recommendations(President 1986), the emphasis has been on staged decision making, the budgeting process, incentive contracting, and the perception of a lack of competition in the defense industry (Clark, Whittenberg and Woodruff 1986, Stubbing 1986). As Coulam (1977) stated in Illusions of Choice, the failure of these attempts to improve the acquisition system's behavior is due to a basic lack of understanding of the structure of the organizations which make up the defense acquisition system and the implications of the structure which leads to behavior stated .

Actually it is not hard to imagine that attempts to change a system which is made up of so many large and powerful bureaucracies (Congress, the Office of the Secretary of Defense, individual branches of the armed forces, and many private firms) interacting in a basically political arena are doomed to failure. It is not clear that the problems can even be understood by limiting a study to only one or two of the system's components, or by using a single paradigm. The system certainly will not be "reformed" by implementing changes within only one of the organizations. The problems in weapon acquisition management are truly systemic in nature.

The studies referenced have all taken a rather limited view of the acquisition system using a single analytical paradigm or approach. The approach taken in each study its focus, the authors and study's results are shown in Table 2. The conclusions from all this activity have not produced policy changes that have altered the basic behavior of the system. Unit weapon costs, in real terms, continue to rise and the numbers of weapons decrease with no indication that implemented policies are having any

beneficial effect. As noted, the key focus of this paper is development of an integrative analytical framework whose purpose is incorporation of the ideas posited in the various studies shown in Table 2. The results of discussions of the evolving framework with executives and scholars in the area also are incorporated.

Place Table 2 About Here

The views of those interviewed are seen as being key to the modelling process because a very broad view of the system has not been documented in the literature, and the interconnections of the subsystems, which have not previously been addressed directly, are of vital importance. Interview comments have not been attributed directly to those interviewed as agreed upon prior to the interview. This was done to ensure that an open discussion could take place. Those interviewed are noted in the references. The conclusions about the system from the literature and interviews are the topics addressed in the remainder of the paper.

SYSTEM STRUCTURE AND OVERVIEW

Decisions about the development and acquisition of arms are made within a system structure that contains four major subsystems each of which has been addressed in some fashion in past studies. These previous studies, noted in the last section, have portrayed the acquisition system from the perspective of either the weapon development/weapon production process (Coulam 1977), the weapon contracting/weapon production process (Fox 1974, Gansler 1980, Peck and Scherer 1962), or have focused on the impact that the threat and strategic policies have on weapon acquisition and defense effectiveness (Fallows 1981, Luttwak 1984). Actually, these perspectives may be viewed as subsystems of

Table 2. Literature Structure

Study Target	INDUSTRY	DEFENSE	NATIONAL	THREAT
CONCLUSIONS	•High Level of uncertainty •Unique market •Low capital investment •High profits •Commercial solutions do not	•Reorganize Mgt •Ineffective incentives •Organization resists change •Technology bias •Acquisition cycle getting longer	•No long term strategy •Micro-management •"Pork-Barrell" •Competition restricts flexibility	•USSR is the threat •Threat used to justify procurements •Requirements process is insulated from threat influence
Method				
Economic Analyses	Peck (1962) Scherer (1964) Baldwin (1967) McKie (1970) Fox (1974) Gansler (1980)	Peck (1962) Scherer (1964) Fox (1974) Weida (1987)	Weida (1987)	
Modeling	Sapp (1971) Barker (1982)	Sapp (1971) Clark (1985)		
Quantitative Analyses	Large (1974) Profit '76 Payoff '80 Stekler (1981) DFAIR (1985)	Hall (1965) Greenberg (1969) Perry (1971) Defense Science Board (1978) Stanley (1979) Dews (1979) Smith (1980) Smith (1981) Beltramo (1983) Lee (1983) President (1986)	President (1986)	
Case Study, Interviews, Personal Experience		Bickner (1964) President (1970) Coulam (1977) Rich (1976) Archibald (1981) Fallows (1981) Luttwak (1984) Stubbing (1986)	Rich (1976) Archibald (1981) Stubbing (1986)	Fallows (1981) Luttwak (1984) Stubbing (1986)

the larger acquisition entity. The effects of threat and global pressures; the setting of national priorities; the weapon development, contracting and production processes; and the interaction of United States' military capabilities with the threat, therefore, form the basis for a systemic model. The defining variables and key actors in each subsystem are shown in Figure 1 along with the interaction between the subsystems.

Place Figure 1 About Here

As shown in the figure, the sectors (usually through specific variables within them) interact with each other with the result being production of some actual level of military capability. In complex systems such as this, the interactions typically are projected through a series of information feedback mechanisms existing between variables (Coyle 1977, Forrester 1961, 1966, Richardson and Pugh, 1981). In subsequent sections of the paper these interacting feedback mechanisms and the variables shown in Figure 1 will be discussed in detail. Hall (1976, 1983), Hall and Menzies (1983) and Axelrod (1976) have demonstrated the importance of focusing on feedback mechanisms when attempting to understand complex system behavior. Before a more detailed analysis, however, a brief discussion of the overall system structure will be given.

The military threat, which to a large degree is used to justify defense expenditures, stems from the perception of Soviet military capability (Luttwak 1984). Even in theaters where the United States would not expect to face Soviet troops, the probability is high that U.S. forces would face military units trained and equipped by the Soviets. For this reason as well as a desire to develop a parsimonious model, the threat sector will include only the Soviet influence. The real concern is not whether the Soviets are the

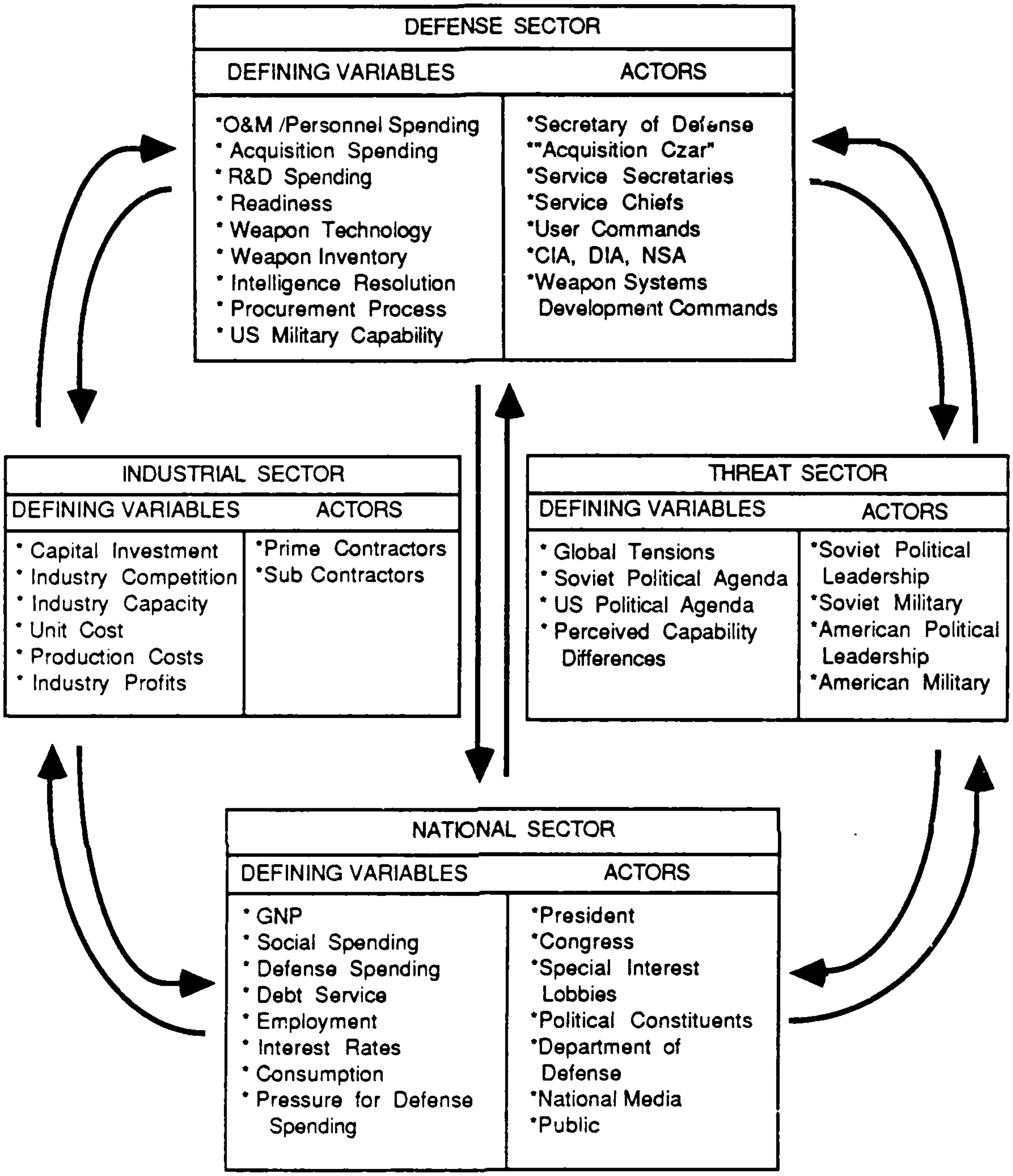


Figure 1. Overall System Structure

only threat the United States faces (they certainly are not) but in the main it is the Soviet threat to which our acquisition system reacts. The interaction of the threat sector with the rest of the system is primarily through the pressure for defense expenditures created by threat and in the increased pressure for specific defense expenditures depending on Soviet advances in technology and force levels, readiness, and intelligence resolution.

The national sector is included to represent the budgeting and resource allocation issues confronting the Government. Much of what is included largely is based on classical macroeconomic theories. The sector incorporates GNP, investment, consumption, interest rate, and three components of the federal budget (defense, social welafare and debt service). Interaction of the federal budgeting sector with the rest of the system occurs primarily through a defense expenditures variable that will be thoroughly discussed in a later section.

The defense sector is included to represent the translation of resource allocations into specific military capabilities. The defense budget like the federal budget is decomposed into the four spending components of personnel, operations and maintenance; acquisition; research and development; and intelligence resolution. The procurement process is represented by several complex variables that will be addressed in a later section. The national and the defense sectors interact with the rest of the system primarily through the pressure for defense spending and military capability elements.

The industrial sector interacts with the other sectors through the relationship between industrial capacity, capacity utilization, and production costs and through the procurement mechanisms in the defense sector. Subsequent discussion will focus the industrial sector and the defense sector

in greater detail than the other sectors.

Presented in the subsequent sections are individual models which focus on the interactions of the key variables in these four sectors. The detailed models will be presented as causal diagrams that provide a detailed focus on each of the relationships and make explicit the feedback nature of the system. Before discussing the system model and each sector, a brief overview of the causal modeling methodology will be presented.

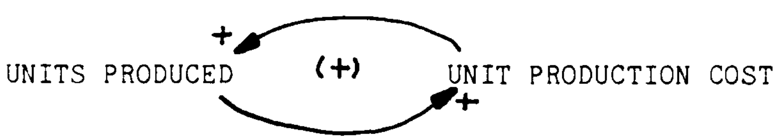
CAUSAL ANALYSIS

A commonly used method for dealing with complex system structures to focus on important interactions and relationships within the system is causal analysis or influence diagramming (Coyle 1977, Richardson and Pugh 1981). Use of this technique requires that the interaction between a pair of interacting variables is considered in turn, and a causal relationship for them is hypothesized. The relationships which are hypothesized in this paper are supported by the literature review and data from the interviews.

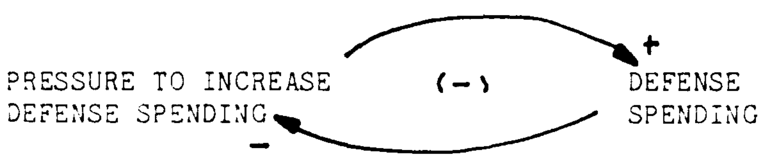
For example, a relationship between the number of weapon system units produced and the unit production cost of those weapons might be hypothesized. The relationship might be such that an increase in the number of units produced would result in a lower unit production cost, that is as units produced goes up there is a tendency for unit production cost to go down as a direct result. To model the relationship, one would pose the question: if the number of weapons produced increases, would the unit cost of those weapons tend to increase or decrease as a result? The answer to the question forms a causal hypothesis, the nature of which is indicated by a plus or minus sign at the head of an arrow drawn from the influencing variable toward the influenced variable. A minus sign indicates that the influenced variable moves in the opposite direction of the influencing variable, a positive sign

would indicate that the variables tend to move in the same direction.

If there is also a causal relationship hypothesized between the two variables such that the influenced variable also directly impacts the influencing variable, that is the relationship exists in both directions, then this relationship is also diagrammed and a feedback loop between the two then exists. In this case, if a change in the unit production cost leads directly to a change in the number of units produced, then a second arrow should be added from the cost variable to the units produced variable. The relationships between these two variables form a feedback loop which, in this case, is positive. That is, the relationships are such that any change in a variable's value is reinforced by the impact of its relationship with the other variable. In the units produced, production cost example, if the number of weapons produced is decreased, the effect would be an increase in unit cost, and as unit cost increased, the number of weapons produced would decrease further, which results in higher unit production costs, and so on. In a causal model this relationship might be portrayed as:



A negative feedback loop, on the other hand, would create a balancing or equilibrium-seeking relationship. For example, if a relationship was formed between "pressure to increase defense spending" and "defense spending" the resulting feedback loop would be a negative one and would appear as:



In this case, as the pressure to increase spending increased, it would tend to

increase defense spending. Additionally, if defense spending increased, the pressure to increase it further would tend to decline or move in the opposite direction. This loop with an odd number of negative signs results in a negative feedback loop. Negative feedback loops are stability producing structures within systems as they often incorporate system goals and goal attainment variables. This methodology will be used in structuring each sector, the first of which discussed is the threat sector.

THREAT SECTOR

The emergence of the United States as a global military and economic superpower following World War II has resulted in current foreign policy based, to a large degree, on the concept of maintaining a balance of power between the United States and its allies, and the U.S.S.R. and its allies (Reichart and Sturm 1983). Maintaining a political balance of power requires that the United States maintain strategic and tactical military forces sufficient to counteract conventional and nuclear Soviet forces and their surrogates worldwide (Luttwak 1984). In many ways, therefore, the structure of the United States' armed forces and defense industrial base has been shaped by the perception of the Soviet threat (Luttwak 1984). Even though the Soviet threat is central to policy debates concerning United States defense policies, some have argued that our policies do not accurately enough reflect the threat which it is meant to counter. In the long run, this perception of the Soviet threat will almost certainly continue to shape American defense acquisitions (Dyer 1985, Luttwak 1984).

The United States and the Soviet Union each has its own political agenda which it attempts to meet. Each has a "desire for global influence." The ability to carry out a global agenda and gain influence is determined, to a large degree, by the ability of a nation to project a global military force

(Dyer 1985, Luttwak 1984). As a result, the Soviet Union and the United States not only increase their respective military capabilities to enable them to carry out political agendas but also as a countering force to influence the other's agenda (Dyer 1985). These counteracting forces are embodied in the threat sector.

The structure of what has been labeled the "arms race" can be clearly seen when only a few of the variables in the threat sector are viewed. The key but simple loop structure in the sector is shown in Figure 2. As long as each nation is willing to accept parity, a relative balance will be maintained but if one has a greater (actually a perception of greater) military capability than the other, spending will increase and the ratio of Soviet to United States capability will alternate and the "race" will be sustained.

Place Figure 2 About Here

At the same time that each nation desires influence, each also would like a world free of what has been labeled "cold war tensions" or simply "global tension." When variables are added to the model to capture this, the sector appears as in Figure 3. Global tensions results, of course, from aggressive behavior by either nation. The ability of a nation to be aggressive is of course a direct result of its desires and military capability.

Place Figure 3 About Here

The basic or core structure of the sector is presented in Figure 3. There are, of course, other forces and a finer level of detail that should be included. Also, the linkage of this sector to the U.S. political sector, will include the structure that provides a limit to defense spending. This finer

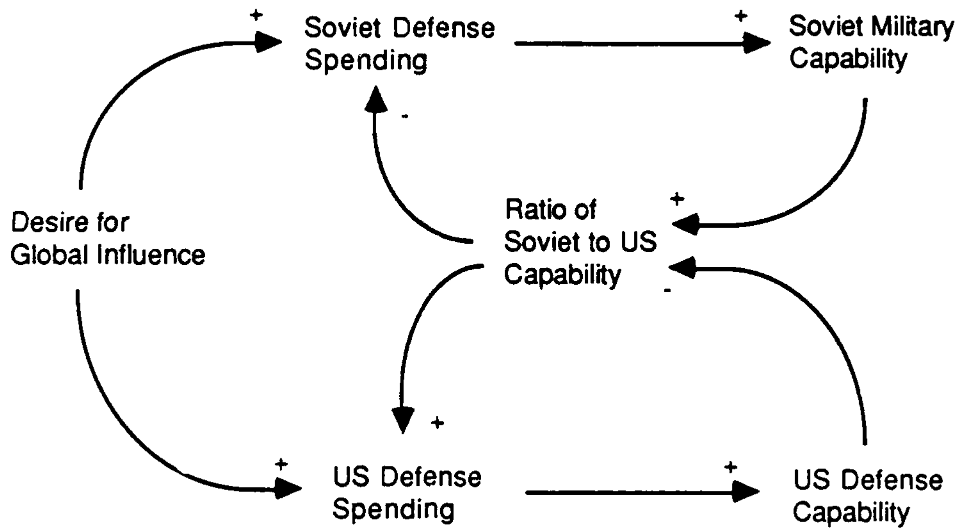


Figure 2. Basic Loop Structure of the Threat Sector

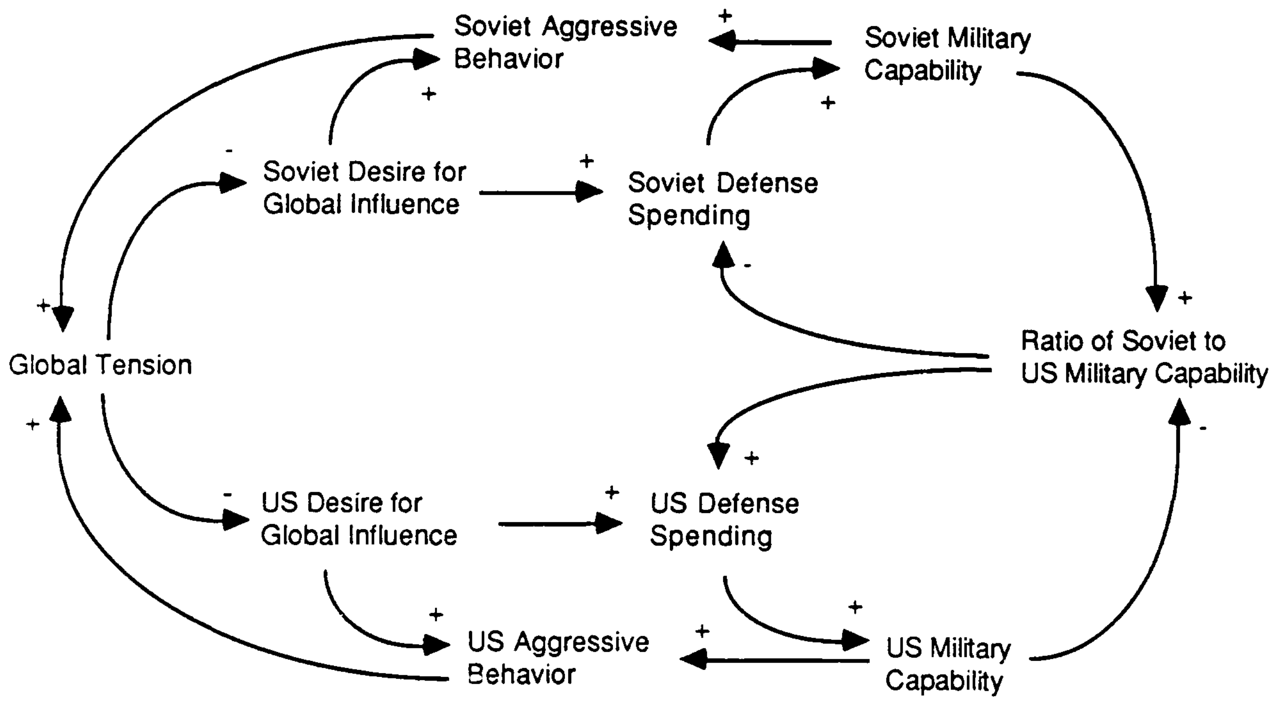


Figure 3. Global Tension Structure

level of detail for the threat sector will be discussed and a more detailed model presented before the linkages to "restraining forces" are added.

While there are some notable exceptions like electronic counter measures, there is general agreement that the perceived threat a nation faces does not seem to directly impact the acquisition of specific weapon systems, the number of weapons which are produced or the tradeoff of weapon quality for quantity (Brown and Korb 1983, Dyer 1985, Fallows 1981). The perception is that the threat is used by the actors in the system to justify a given position on arms acquisition (Dyer 1985, Fallows 1981, Luttwak 1984). The result is that the weapons procurement process seems to be quite well insulated from a threat influence and thus does not respond to individual threat capabilities, especially in the short term. In reality, the process of defining a requirement for a weapon, designing the weapon, developing and producing it has become so lengthy that intelligence estimates a decade or more in advance are required. Intelligence estimates of current capabilities are not necessarily completely accurate and estimates of capabialities ten years hence contain much more uncertainty. Because of this inherent uncertainty, "perceived threat" and its determinant "perceived capability" must be introduced into the model to accurately represent the actual threat reaction phenomena.

Global tension actually is a measure of how close the superpowers are to open conflict, either directly or through surrogate forces. Global tension is a primary determinant of the pressure for defense spending in both the United States and the Soviet Union. The variable increases when a country's aggression increases, and when a perceived shift in the balance of power occurs due to a change in perceived military capabilities. It is the desire to avoid war that tends to mediate aggressive political behavior on both sides

and causes the desire to reduce tensions variables to fall (Dyer 1985). These variables rise with an increase in global tensions.

Military capability also is a complex variable. It is determined by the level of defense expenditures in four distinct categories. Expenditures can 1) increase weapon technology, 2) produce larger weapons inventories, 3) increase readiness levels through training or 4) can be used to either increase ones own intelligence resolution or decrease the intelligence resolution of an advisory. Technology and inventory size must be differentiated because the United States distinguishes between the two components in its weapons procurement policies and it is an effective means for modeling differences in weapon capabilities. Soviet technology is impacted directly by the level of United States' weapons technology and its own intelligence resolution that result in both the legal and illegal transfer of technology.

Because of faulty intelligence, incorrect analyses, or biases in the threat assessment systems, the perception of the threat may differ from the actual threat stemming from military capability differentials. In both the Soviet Union and the United States, it is certainly the perceived threat which drives the desire for additional capability and not the actual capabilities which are probably unknown (Dyer 1985). The overstatement of threat capabilities is a common intelligence reaction to a demand for future threat assessments that has the unintentional impact of increasing the level of global tension and results in pressure on opponents to develop a capability to counter the capability which has been developed to counter an overstated threat capability (Dyer 1985). Just as in the requirements determination process in which the services take a conservative approach (it is better to err on the side of overestimating requirements than the alternative), the

intelligence community deals with the inherent uncertainties by tending to overestimate threats rather than underestimate them.

The impact of intelligence functions and perceptions on the acquisition process is included in the model through the intelligence resolution and perceived capability variables. The additional variables and more detailed structure allow representation of the effects of threat assessments, technology transfers, counter intelligence strategies and perceived military capabilities. They also allow for the determination of the impact of incomplete and inaccurate information on the system. Adding this structure results in the more complex sector model shown in Figure 4.

Place Figure 4 About Here

The level of detail allows meaningful loop analysis that increases our insight of how the system might behave under differing policy alternatives. For example, careful study of the loop structure shows that an excellent way to stabilize the arms race may be to have free and open inspection by both sides of each others capability. This is, of course, very unlikely but the system's structure would indicate that accurate information would reduce the rate of spending. It is the rate of spending which becomes the focus of the next sector discussed.

NATIONAL SECTOR

The primary reason for including a sector relating the political process of Federal budgeting in a defense acquisition system model is that defense spending levels, of course, are determined in that process. It is well recognized that increased defense spending can have important effects on national economic policies and stability. The purpose is not to model the

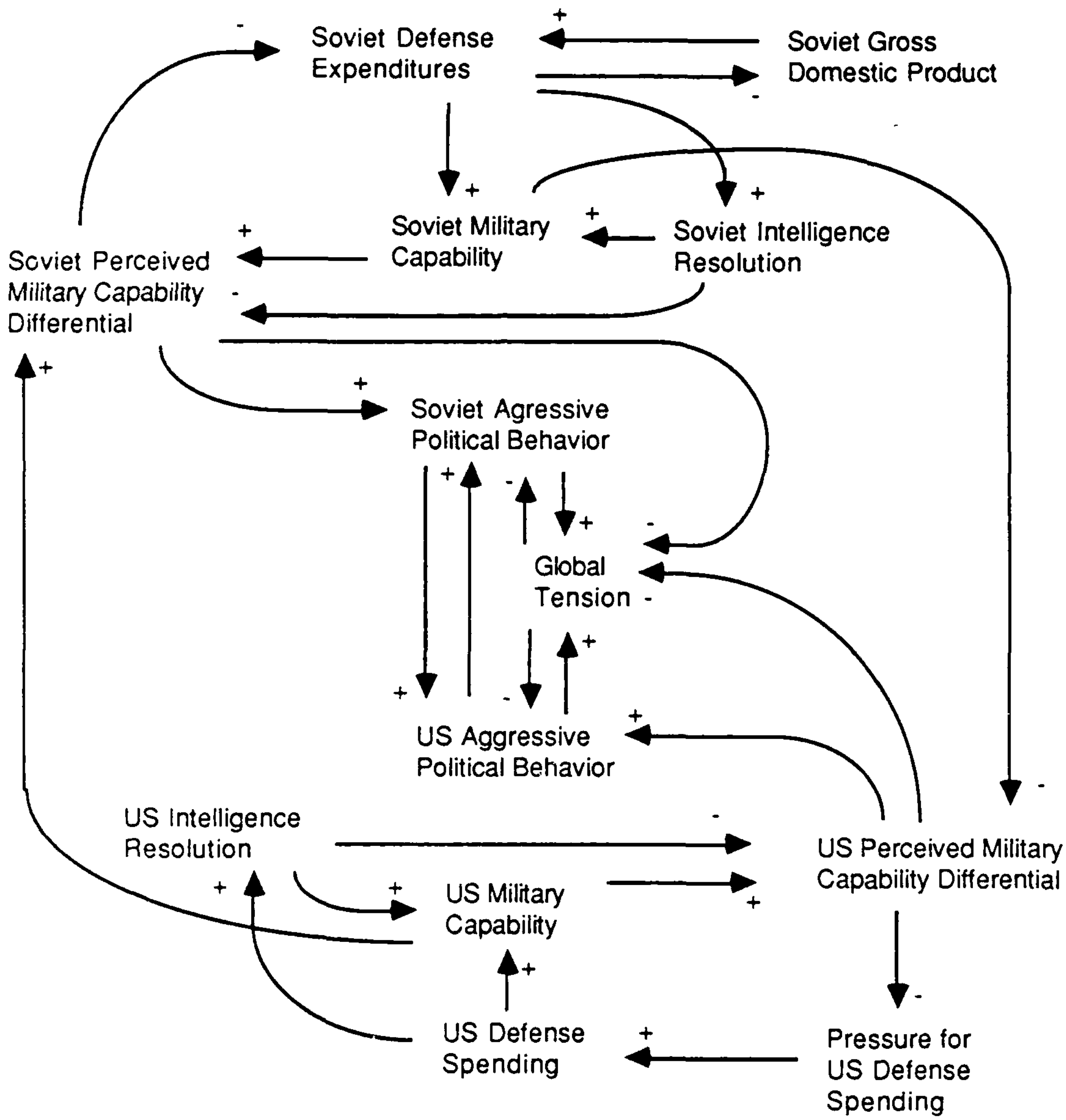


Figure 4. Threat Sector Complex Structure

United States economy or the budgeting process in great detail, but rather to represent these elements effects on acquisition system behavior.

The key loop in this sector reflects the significant political pressures inherent in current defense spending levels and the size of the budget deficit. The interactions among the key elements are shown in Figure 5. The variable introduced in the tension sector, United States Defense Spending, is the key link between the two sectors. As it grows, the federal budget will increase and all things equal, so will the budget deficit. This growth in the deficit has produced increasing pressure to balance the budget by reducing spending. These forces are reflected in the figure.

Place Figure 5 About Here

The detailed structure of the national sector is based on accepted, classical macroeconomic theory which postulates that national income (GNP), consumption, interest rates, government expenditures, investment, taxes and employment levels are all linked together and can be modelled as a system of simultaneous equations. National income (GNP) is affected positively by investment, consumption and government spending. Growth in GNP results in increased consumption stemming from higher incomes and in higher government spending stemming from higher tax revenues. The countering force to these positive effects is the interest rate which, as it rises, acts to reduce investment and decrease consumption. Interest rates rise and fall depending on the relative positions of the money supply and money demand. As money demand rises due to increases in government borrowing or increases in investment interest rates rise to attract more money. If money supply rises relative to the demand for money then interest rates drop which encourages borrowing. These forces are shown in Figure 6.

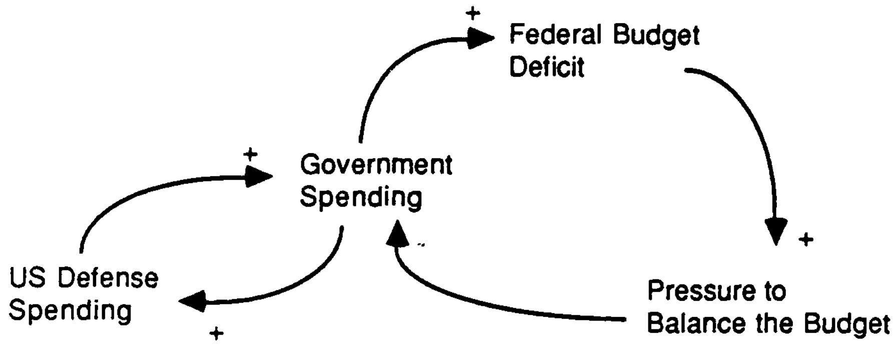


Figure 5. Basic National Sector Structure

Place Figure 6 About Here

Because of the expectation of increased profits from meeting expanding demand with expanded capacity, both employment and investment tend to rise with increases in consumption (Gapinski 1982). When interest rates increase, savings become more profitable increasing the supply of money and bringing interest rates down toward some equilibrium point (Gapinski 1982). The additional structure is represented in the causal map of Figure 7.

Place Figure 7 About Here

A key element in the sector is the size and rate of growth of the national debt stemming from budget deficits. There is considerable support for the idea that the national budgeting process does not make tradeoffs between defense and social spending directly, but rather increases each based on independent criteria (Stubbing 1986). The true mediating variable is the debt service component of the budget and the pressure to reduce the rate of the increase in the national debt. This structure is in agreement with the implications of the cybernetic paradigm of organizational decision making (Steinbruner 1974) which holds that complex tradeoffs tend to be avoided. An excellent example is the recent defense buildup which has not been accompanied by significant reductions in social spending, but rather by record deficits (Fallows 1986, Stockman 1986). Pressure to reduce the deficit is impacted by the debt service component, and social and defense spending pressures and manifests itself in either or both lower federal budgets and increased tax rates.

Three budget components are reflected in the complex model of the sector shown in Figure 8: defense spending, debt service and all other spending.

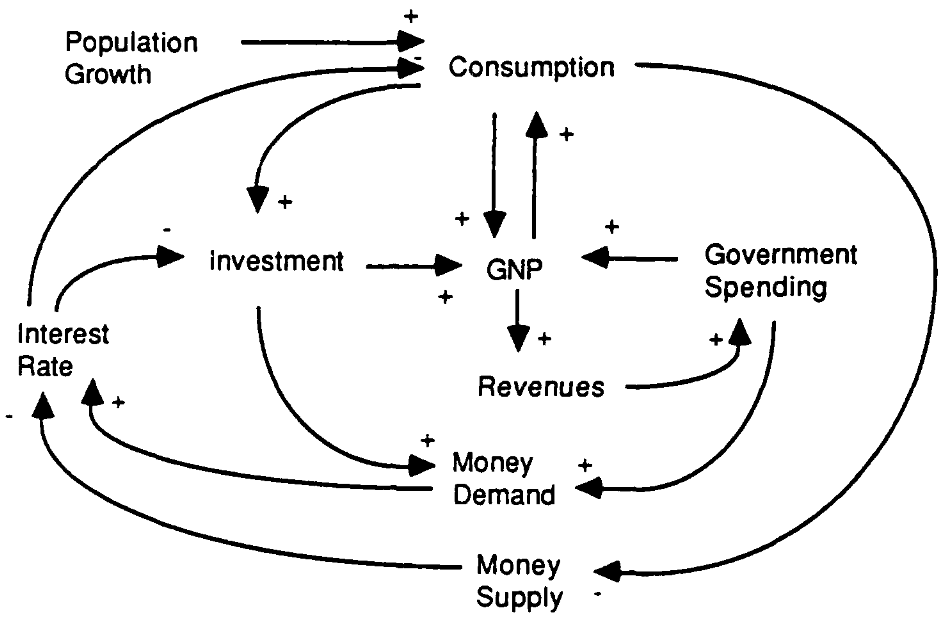


Figure 6. Spending and Investment Structure

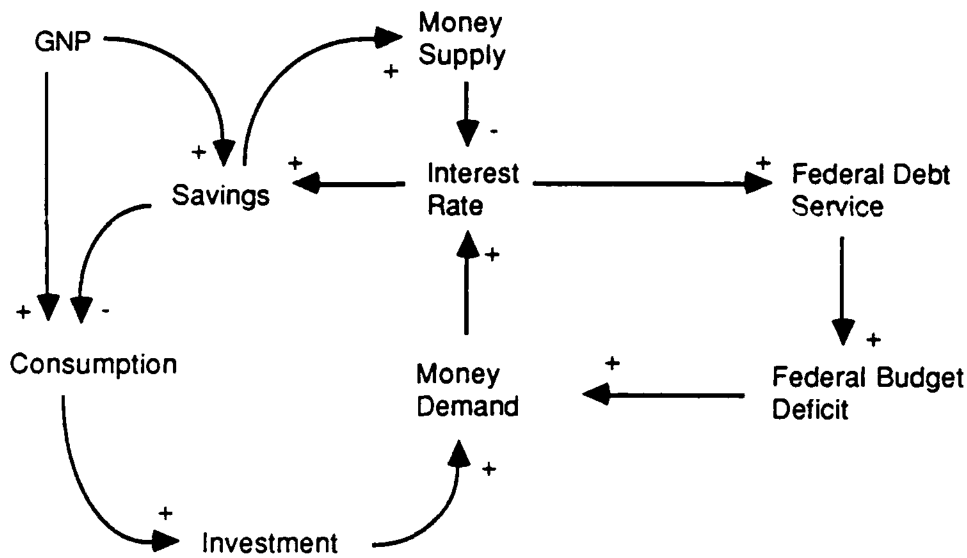


Figure 7. Savings and Money Supply and Demand Structure

The other spending category is labeled "social spending" even though the label may not accurately reflect all that comprises this component. More detail is not required because the defense spending component is of primary concern. Additional economic variables are included to capture the concepts discussed earlier. As discussed earlier, the structure used is well grounded in macroeconomic theory. It is not the intent of the model to explain the national economy, but simply to represent the influence of the current state of the economy on the acquisition process.

Place Figure 8 About Here

Inherent in the difficulty of the Congress to make tradeoff decisions when deciding on spending levels is the process which is used to allocate funds to the defense budget and specific defense line items. Richard Stubbing (1986) makes a compelling case that political and corporate pressures which affect defense budgeting preclude any practical or planned ordering of priorities both within the defense budget and in the national budget. Even without corporate pressure, Congressmen find it very difficult to make defense budget tradeoffs that adversely impact their home districts. Base closings and weapon program cancellations which impact constituents are routinely opposed. As a result, many weapon-system production rates have been slowed dramatically with attendent increases in unit cost. The objective, of course, is to keep production lines open and preserve jobs. At times the armed services have exploited this political behavior forming political alliances with congressmen to defeat cancellations of systems or attempts at reform. The B1 is the most visible example of this (Kotz, 1988).

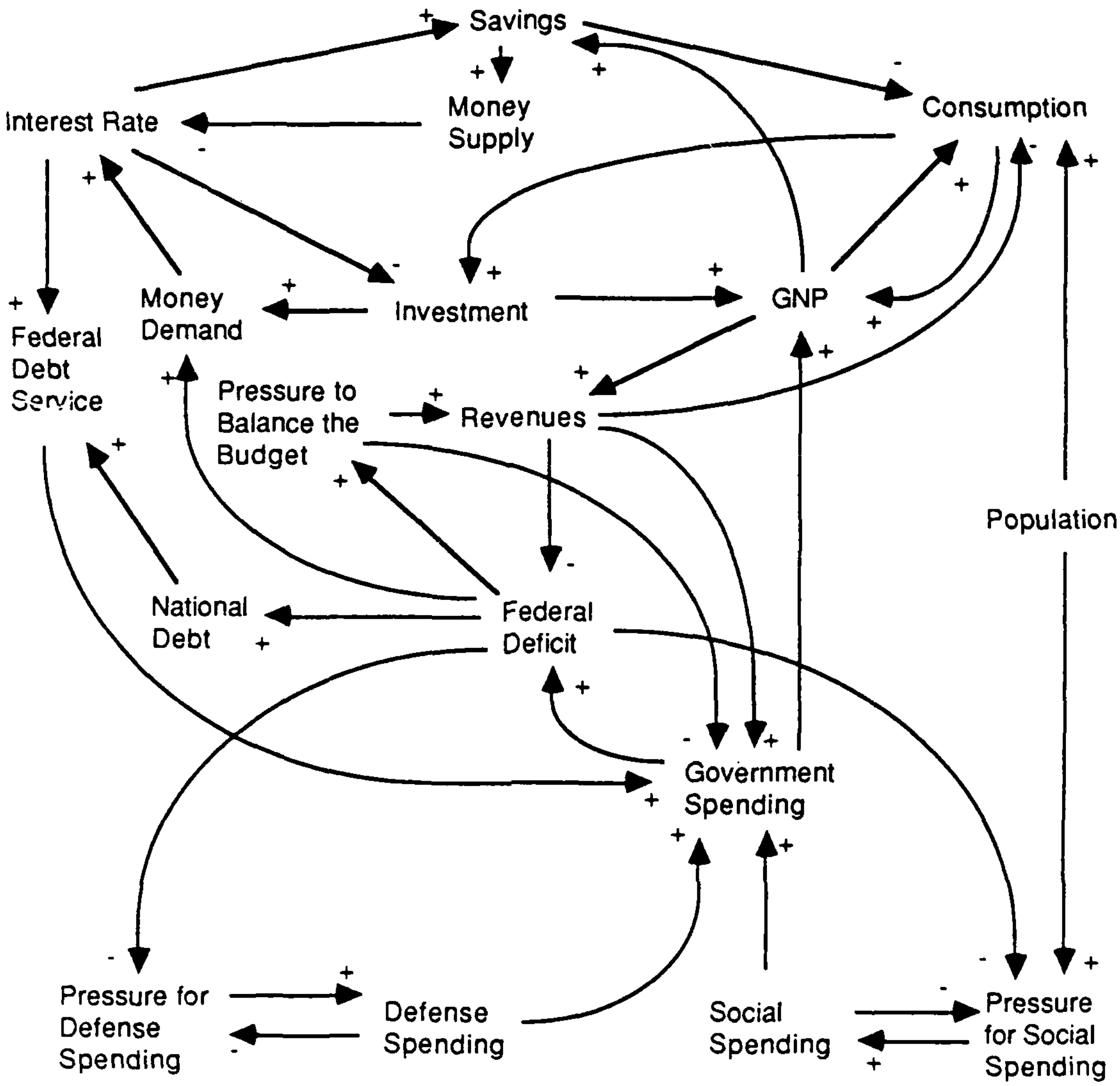


Figure 8. National Sector Complex Structure

DEFENSE SECTOR

Since the primary objective of this research is to provide a useful tool for Department of Defense policy analysts, greater model detail and resolution is given in the defense sector. A second reason for additional detail in this sector is that most of the people interviewed believed that any restructuring of the acquisition system is more likely in this sector than the others. The defense sector structure determines, to a large degree, the behavior of the industrial sector and the effectiveness of the overall weapons acquisition system in terms of its ability to efficiently procure weapons (Coulam 1977, Fallows 1981, Gansler 1980, President 1986). The influences outside of the defense sector (threats to our national security, national budgetary policies, and industrial policies) have an impact, but it is the interaction of the outside factors with the defense sector, and the Department of Defense in particular, that creates much of the behavior which has been identified as being in need of improvement (Fallows 1981, Gansler 1980, Stubbing 1986).

The defense sector is modelled around the key relationships between the defense budget components: operations, maintenance and personnel (O&MP); acquisition, research and development (R&D); and the intelligence effort. Expenditures in these categories result in the major systemic outputs of readiness, weapon inventory, technology produced, and intelligence resolution. These results of defense spending (readiness, weapon inventory, weapon technology, and intelligence resolution) determine the military capability of the United States which, when compared individually and collectively to the military capability of the Soviets, generates defense spending pressure. The interaction and processes of this sector, therefore, form a significant positive reinforcing structure that is a key element in overall system behavior. This basic structure, which will later be expanded

is shown in Figure 9. The development of the basic structure shown in Figure 9 will be pursued in the remainder of this section of the paper.

Place Figure 9 About Here

Priorities within the defense sector, like those in the national sector, are best represented in the budget figures for different defense accounts. The defense budget has been broken down into four separate accounts along threat lines rather than by service components as is done in the individual Departmental budgets. This aggregation across services reflects the threat sector structure, where no service distinctions were made. For threat, there is a near term component (Soviet readiness), a medium term component (Soviet weapon inventory), a long term component (Soviet weapon technology) and a Soviet intelligence resolution component that exerts influence in each time dimension. This breakdown loosely parallels current defense accounting procedures (Foelber 1985). The categories shown in Figure 10, and what they yield will be discussed in detail.

Place Figure 10 About Here

The first component of the defense budget is the research and development (R&D) account. The purpose of R&D spending is the development of new weapon technologies which embody both "force multiplier" technology and "reliability and maintainability" technology. The first type, force multiplier, increases the effectiveness of a given system and the second type, reliability and maintainability affects its availability. The pressure to increase R&D spending comes from the current levels of weapon technology available, the current levels of weapon reliaiblity and maintainability, and the technology level of Soviet weapons (Fallows 1981, Luttwak 1984). Although a comparison

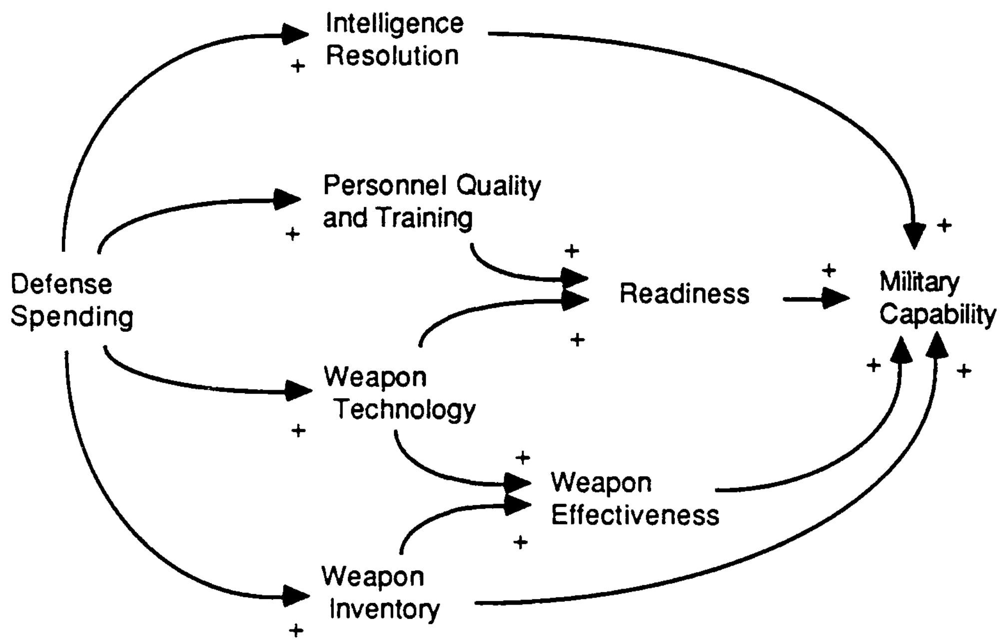


Figure 9. Defense Sector Basic Structure

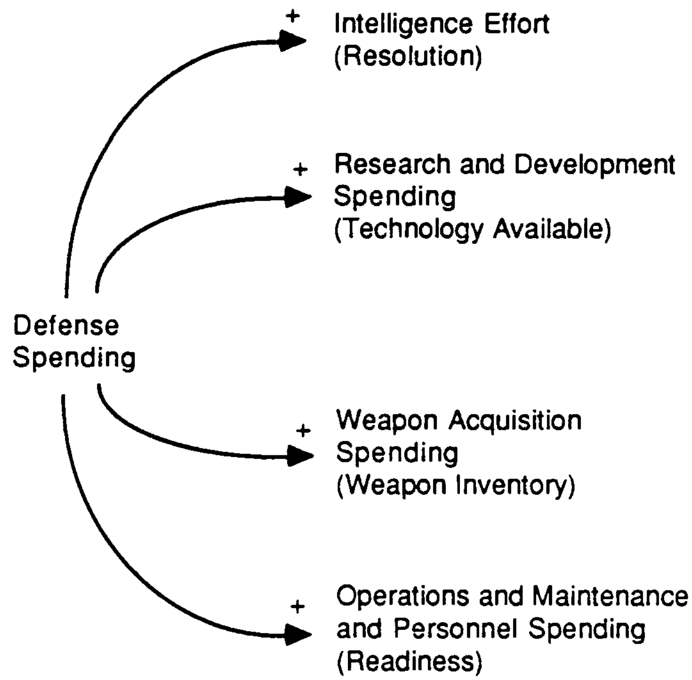


Figure 10. Defense Spending Categories

of available technology with Soviet technology should determine United States R&D spending requirements, the determination of the balance between Soviet and U.S. technology is not easy to make, so other factors often impact R&D spending levels.

Because weapon technologies that are developed are not always produced (Luttwak 1984), a distinction between technology available and technology produced must be made. The United States military depends, as a matter of national policy, on a technologically superior force to overcome the numerical advantage that the Soviets have in many potential military confrontations. To some, it is this dependence on state of the art weapon technology that drives current acquisition policy and has led to rapidly escalating weapons costs (Brooks 1983, Coulam 1977, Fallows 1981, Gansler 1980, Luttwak 1984).

Although maintainability technology received much less attention than force multiplier technology development prior to the 1980's, its impact upon United States military capability can be significant because of the adverse impact that highly complex weapons can have on maintenance effectiveness and readiness (Fallows 1981). The employment of high technology weapons tends to increase the maintenance requirements initially, while the development and implementation of reliability and maintainability technology lowers it. The current operational readiness rates of the Air Force and Navy's most advanced figher aircraft (in the 90% range after being below 50% only a decade ago) indicate the impact of increased emphasis on the reliability and maintainability issues.

The relationship between the number of systems developed and the number of systems produced provides a check on R&D spending. Weapons cannot be acquired until they have gone through the development phase, so the number of weapons which have been developed places an upper bound on the number of

systems which can be produced. Pressure for weapons purchases and development will build up if too few weapons are being produced. These forces are shown in Figure 11.

Place Figure 11 About Here

The second component of the defense budget is the acquisition account. Pressure to increase the rate at which weapons are developed and acquired comes from a wide variety of sources including: the assessment of threat capabilities; the assessment of the United States' weapon inventory and military capability, the technological age of the current inventory; and various political considerations (Fallows 1981, Stubbing 1986). An increase in acquisition funding results in buying more weapons as well as stimulating the development and purchase of brand new weapons. The purchase of brand new weapons is dependent upon the availability of new designs resulting from previous R&D spending, so the production of new weapons as a result of a defense build-up usually lags other spending increases (Stubbing 1986). The key relationships here include: the tendency for unit cost to go down as the number of units procured goes up, the number of units procured to vary inversely with the number of different systems produced, and the increase in the length of time to develop and produce a weapon that comes with the larger number of weapons in production and development. These relationships are at the heart of the interaction between the R&D and acquisition functions. The addition of acquisition spending is shown in Figure 12.

Place Figure 12 About Here

Shown in the defense sector figure are the key variables which impact the unit costs of weapon systems. They are the system development rate, the level

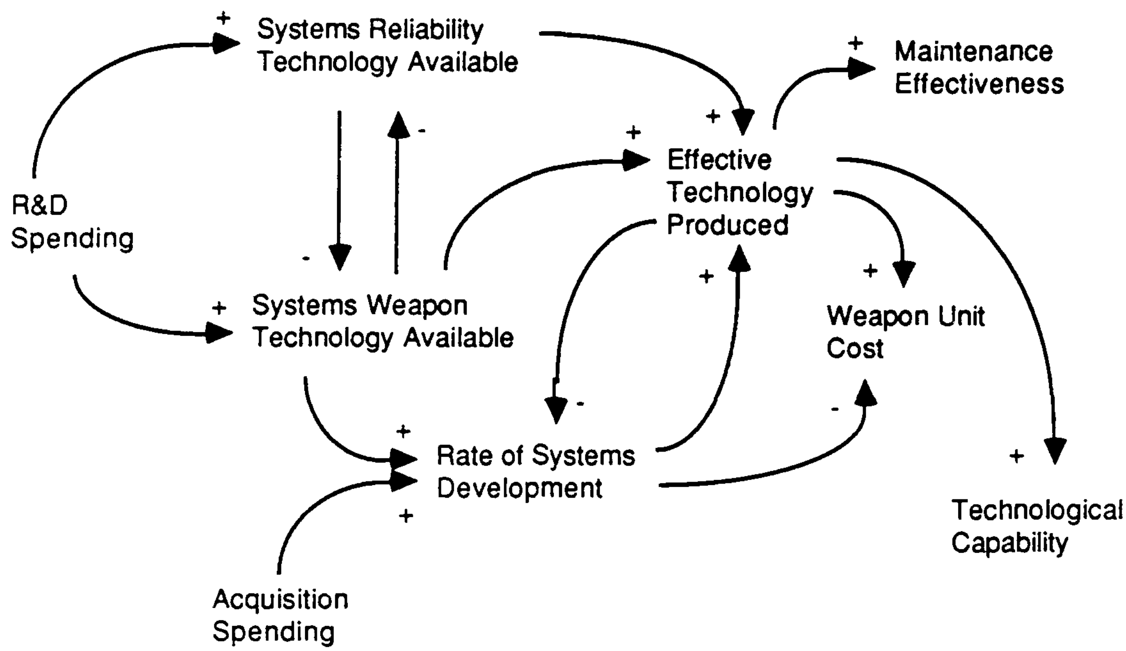


Figure 11. Research and Development Spending Structure

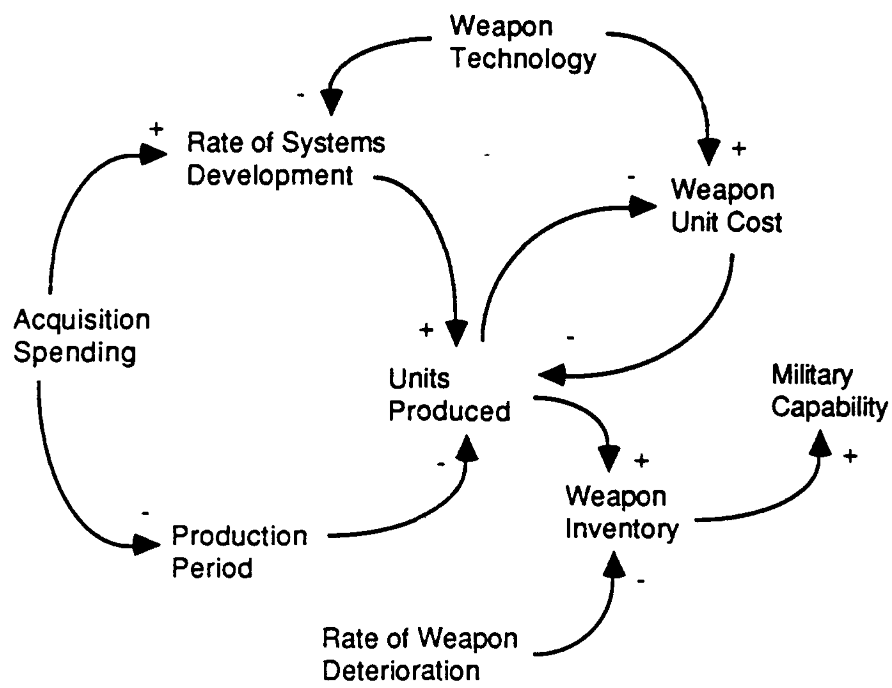


Figure 12. Acquisition Spending Structure

of weapon technology produced and the production period (Bickner 1964, Coulam 1977, Gansler 1980, Lee 1983, Perry 1979). The observation that longer development periods were leading to costing more in the long run, more expensive weapons led to the policy of concurrent development and production in the 1960's (Coulam 1977). In many cases, however, it was the lack of prototyping and effective testing and evaluation that led to extensive modification of weapons already in production and thus caused, in reality, longer development and much higher unit costs (Coulam 1977). The F-111 is the most notable example. Gansler (1980) noted that the technology produced also increased the lead time required by industry to produce the weapons which further lengthened the production period.

Fallows (1981) speculated that the desire for increased weapon capabilities was only partly due to the desire to offset the numerical disadvantage that the United States faces, but also was affected by the budgeting process. He observed that as soon as a firm number of weapons is agreed upon by the Department of Defense and Congress, the services push to make them as capable as possible. Gansler (1980) identified similar pressures when he observed that the "hi-tech" workforce that makes up the defense industry has a predisposition toward state of the art technology, independent of any military requirements. The effects of these forces on unit costs is shown in Figure 12.

The result is that the United States buys, as a matter of policy, extremely complex weapons but not always to counter a confirmed threat (Luttwak 1984). These highly complex weapons often require more complex maintenance, more highly skilled operators and technicians, often result in lower initial readiness are more expensive to produce, are procured in much smaller numbers, and are much more difficult to accurately budget for as cost

estimates tend to be less accurate (Augustine 1985, Coulam 1977, Fallows 1981, Lee 1983, Luttwak 1984, Perry 1975). It is a little strange that much of the discussions having to do with defense spending highlight the fact that the United States is at a sometimes severe numerical disadvantage, yet our acquisition policy is based on ensuring that this is the case as fewer and fewer high cost weapons can be purchased (Fallows 1981). Luttwak (1984) made an even more disturbing observation when he wrote that not only is the United States buying too few of the high technology weapons, but the technology that is bought is not always well grounded in operational necessity. This, of course, is a restatement of the often observed "gold-plating" the armed services practice.

In many cases, weapons acquisition pressures result from the desire to counter specific threats but also from the desire to maintain a large defense to counter the aggregated threats to national security and to maintain a position of world leadership (Luttwak 1984). The development of an extremely large and complex defense bureaucracy with too little responsibility spread among too many bureaucrats has resulted in a system where internal threats, for example inter-service rivalries, and Congressional micromanagement seem to drive acquisition actions as much as do threats to national security (Coulam 1977, Luttwak 1984, Stubbing 1986).

The third defense budget component, operations & maintenance and personnel (O&MP), includes spending for the procurement of spare parts, munitions and personnel training: This component typically is the most sensitive account to spending cuts (Foelber 1985) and is often the first account to be increased when spending levels increase (Fallows 1981). This probably is due to the nature of defense budgeting where acquisition outlays

lag behind acquisition obligations, whereas O&MP outlays are nearly all accomplished in the current year.

Increased stocks of spares and munitions directly increase readiness (Luttwak 1984) and the effectiveness of the maintenance function, as less down time and cannabilization are necessary (Lee 1983). Increased training also directly increases readiness as operations and maintenance effectiveness are increased (Luttwak 1984). At the same time, increased training tends to increase maintenance requirements, expenditures for spare parts, and munitions, and results in the loss of some equipment. Pressure for increased O&MP spending results from the perceived level of readiness of the military, which is the result of O&MP spending, as well as the global tension variable, which is associated with a near term threat. These forces are shown in Figure 13.

Place Figure 13 About Here

The final component of the defense sector is the intelligence effort and the associated military capability component, intelligence resolution. This component is presented in more detail in the threat sector. The presumption that the next superpower confrontation will be a "come as you are affair" (Dyer 1985) places great pressure on the strategic intelligence function which must provide early warnings of conflict and assure proper development of forces. The resolution of the military intelligence function, therefore, is a significant component of military capability. The intelligence components introduced in the discussion of the Threat sector are shown in Figure 14 along with the other elements introduced earlier.

The links to the industrial sector of the system also are shown in Figure 14. The number of weapon units actually produced and their costs become the

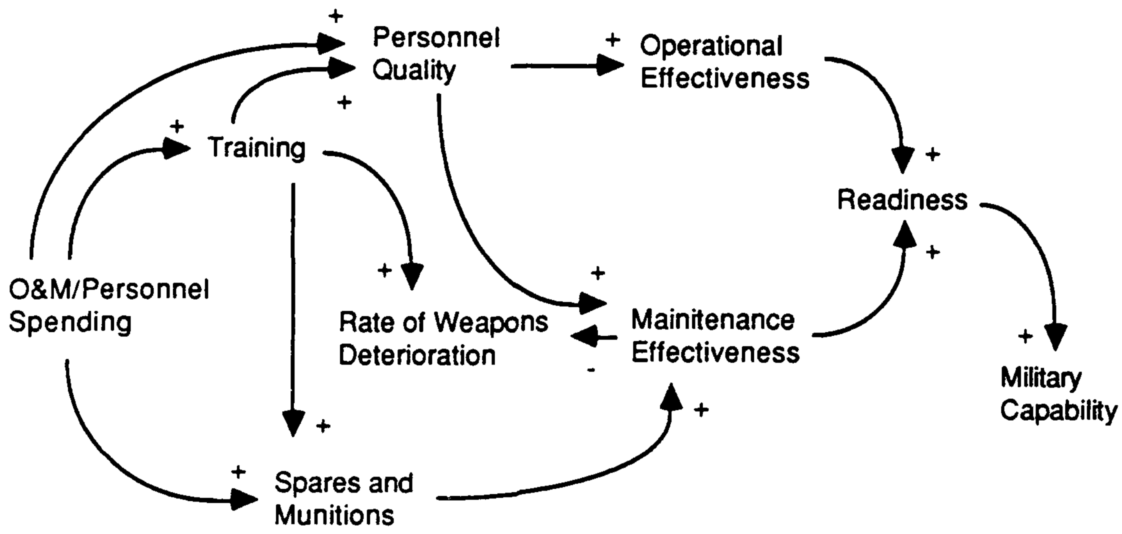


Figure 13. Operations and Maintenance/Personnel Spending Structure

focus of that sector. The structure of the industrial complex part of the system is the subject of the next section.

Place Figure 14 about here

INDUSTRIAL SECTOR

There are several excellent studies of the relationships between the national defense establishment and the United States' defense industry including: The Defense Industry (Gansler 1980), Arming America (Fox 1974), and The Weapons Acquisition Process (Peck and Scherer 1962). These studies, and others, have provided the basis for the industrial sector structure presented in this section. Despite recent news stories which have blamed the high cost of weapons, spare parts and other military equipment on greed-inspired over-pricing by individual defense contractors, the conduct of the defense industry and the prices which are charged for weapons and spare parts are more likely due to the structure of the system in which contractors interact with each other, the Congress and the Department of Defense.

Since World War II, the ability of the defense industry to deliver high quality, low cost weapons to the Department of Defense in a timely manner has deteriorated at an increasing rate (Fox 1974, Gansler 1980). In large measure, the increases in cost and production schedules are due to matters beyond the industry's control. The conclusions of most of the economic analyses of the defense industry have been that competitive market forces, which might exist in a classical monopsony market (one buyer and multiple sellers), have been negated by the procedures, regulations and actions of the Department of Defense and Congress.

The basic structure which has evolved in the defense industry is much the same as for any other industry but with some key differences. The important relationships which define the defense industry structure are contained in the

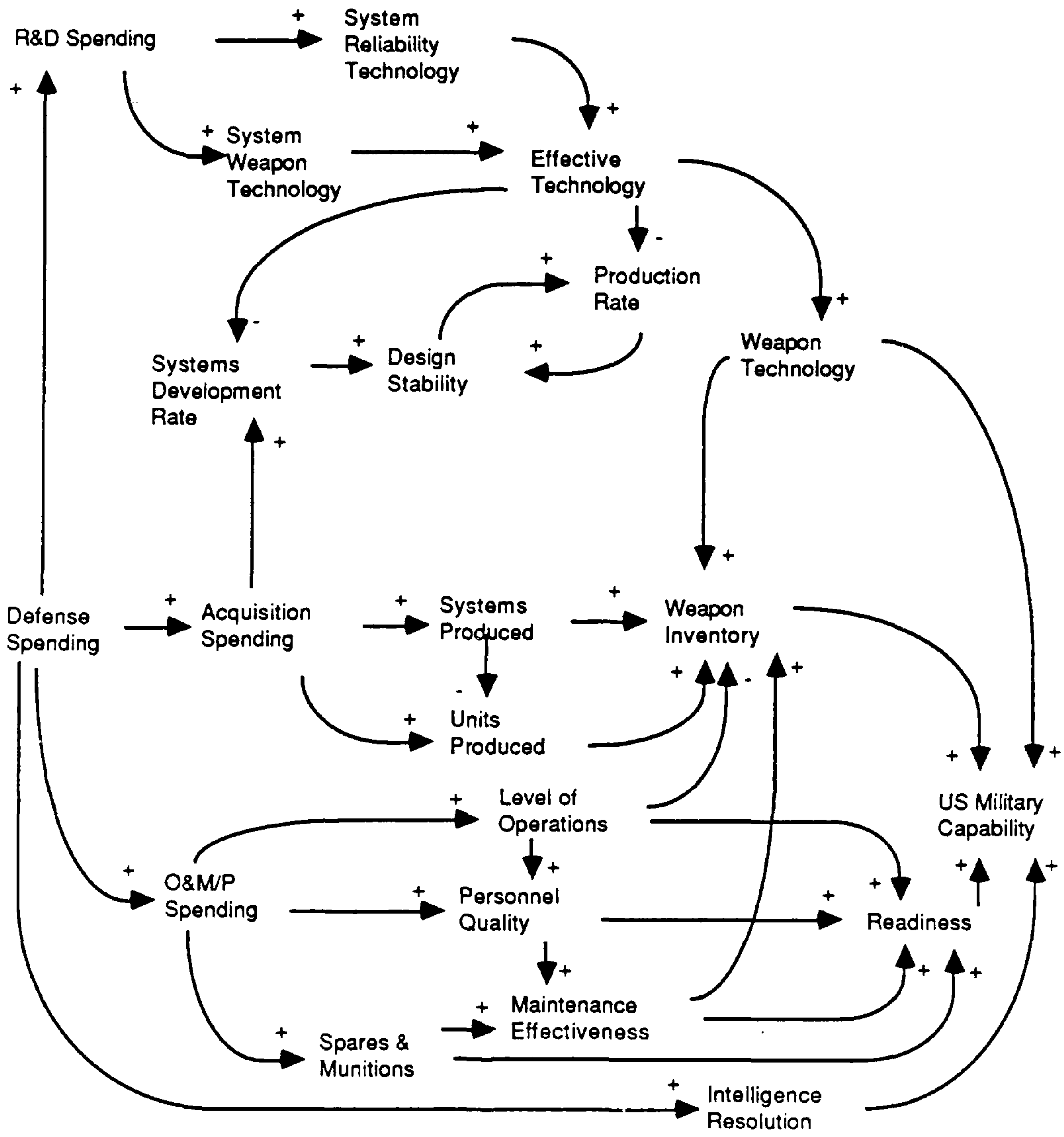


Figure 14. Defense Sector Complex Structure

capacity feedback loop, the unit cost feedback loop, and their interactions shown in Figure 15. The "weapon unit cost" variable is the critical element that is determined in the industry sector and that provides the key linkage with the defense sector. Weapon unit cost in this sense is the cost to the Department of Defense, it includes production cost and the contractor's profit. It is composed primarily of production costs which are influenced by the level of industrial capacity utilization. Industrial capacity incorporates production technology and directly results, of course, from the industry's capital investment (Gansler 1980). Also adding to unit costs is the technology incorporated into a given weapon system.

Place Figure 15 About Here

In addition to the basic structure shown in Figure 15, there also are significant peculiar economic and political forces which shape the defense industry's structure. Large economies of scale exist in the production of weapons. Because a firm needs a highly technically trained labor force, large capital equipment leases and extensive management structures to prepare and manage bids to meet government standards, there are relatively few contractors capable of bidding on any defense contract (Gansler 1980). These large economies of scale act as a barrier to entry for other firms which might wish to enter the market when profits are high. This tends to make the market concentration move in only one direction: firms can leave but none can enter. Market concentration, the number of firms in an industry, is often used as a measure of industry price competitiveness. The relationships between weapon unit cost, industry concentration, profitability, and the risks which the individual firms perceive is presented in Figure 16. The use of foreign military sales and subsidies from the Department of Defense in the

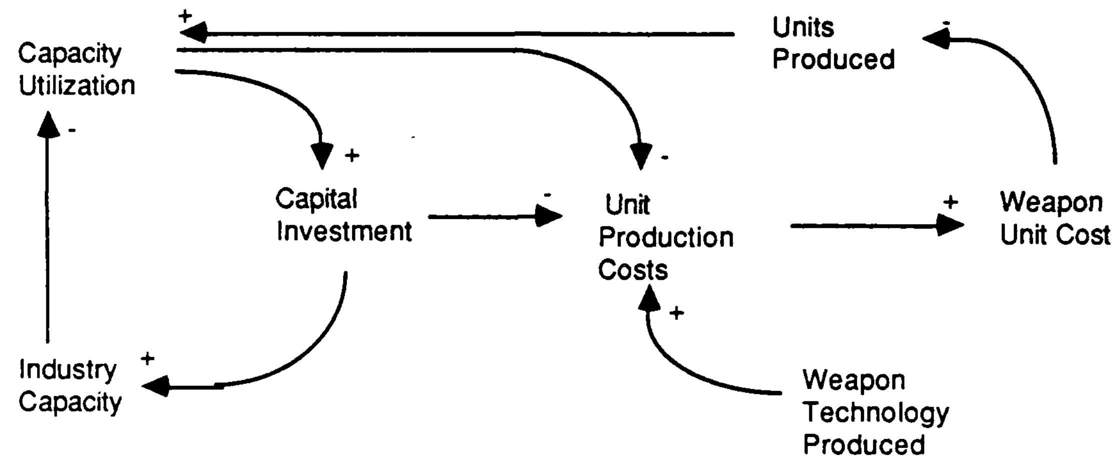


Figure 15. Industry Capacity and Investment Structure

form of bailouts and renegotiated contracts have been used to cover losses and reduce contractor risk in order to maintain the contractor base.

Place Figure 16 About Here

These basic economic structures exist in a highly charged political environment in which competing interests have various ideological and economic status. Political pressures from industry and other constituencies can be used to extend production runs, often at very low production rates, or to avoid cancellation of given weapon systems. The major impact of this politicizing of the acquisition process is that weapon systems are rarely cancelled resulting in longer production periods for the systems in production and in lower production rates. Long production periods in the past have increased the pressure for concurrent production and development (Coulam 1977) which tends to increase production costs as the design is modified repeatedly during production. The B-1 bomber offers an excellent example of how political forces affect procurement (Kotz, 1988). This structure is presented in Figure 17. Factors which contribute to the inability of contractors to meet contract

requirements include: the uncertainty of estimating high-technology weapon costs, the tendency of the services to increase or resist reduction of the capabilities requirements, and changing production schedules due to budget instability.

Place Figure 17 About Here

The Department of Defense has followed a strategy where technology has for the most part been used to maximize the performance of individual weapon systems rather than to lower production costs and improve system effectiveness simultaneously as is done more commonly in other industries (Gansler 1980).

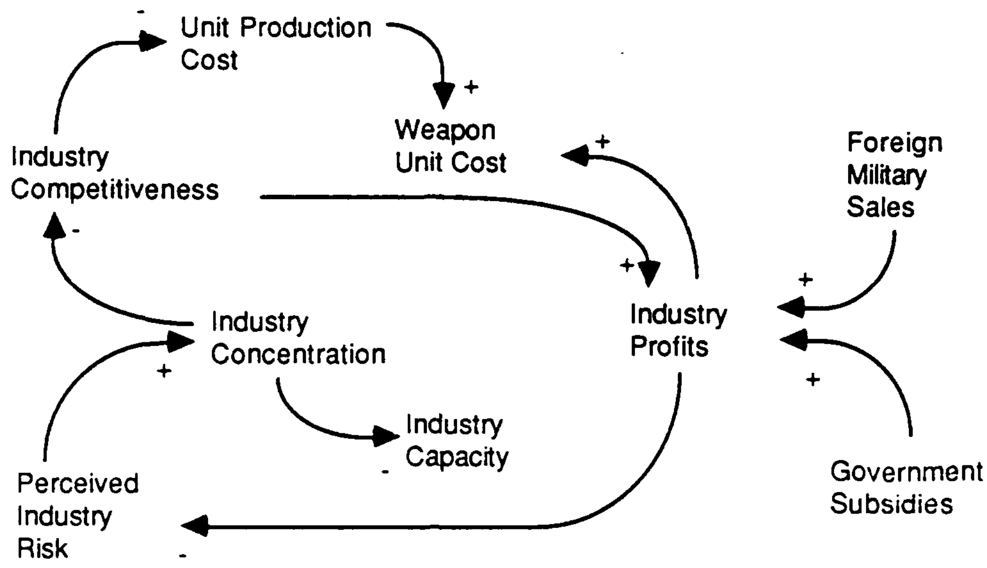


Figure 16. Industry Concentration and Competitiveness Structure

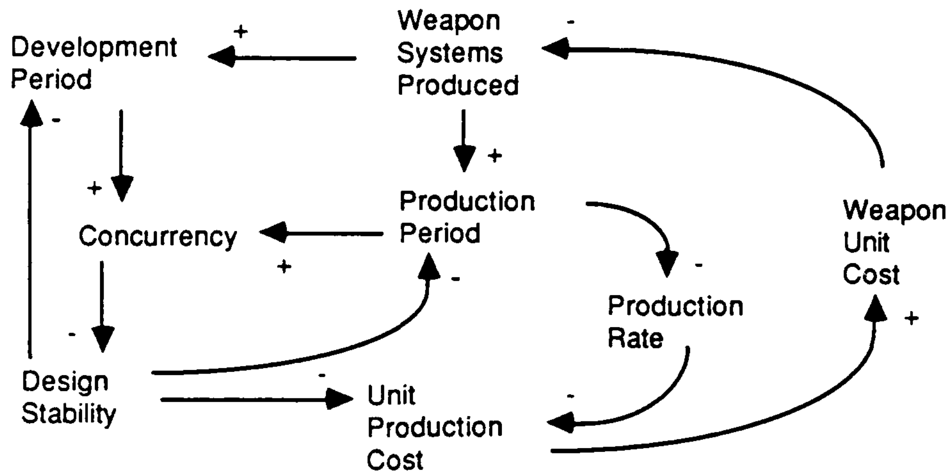


Figure 17. Development, Production and Cost Structure

Industry capital investment which could lower production costs has been the target of many incentive contracts in the past (Coulam 1977), however only in the F-16 and similar programs where subsidies in the form of investment seed money was provided have firms invested heavily and effectively. Much has been made of the low levels of investment by defense contractors (Barker and Konwin 1982, Gansler 1980) however this does not seem surprising from an industry where the natural competitive forces which would encourage investment in low cost production capabilities have been negated by increased risks. The key factors affecting weapon system unit costs include: design and budget stability, the level of industry competition, production costs, the number of systems procured, and the weapon technology produced.

Capital innvestment by the industry would have the dual affect of lowering production costs at the same time as raising industry capacity, and lowering capacity utilization. However, lower capacity utilization results in less pressure to invest in capital equipment. The feedback loop between industry capacity, capacity utilization and capital investment indicates that the overcapacity situation which exists at the prime contractor level, and is made worse by the government providing plants and equipment, must be addressed before a significant improvement in the investment practices of the prime contractors can occur. The economic and political forces which shape the industrial sector are represented in Figure 18 along with the Department of Defense policy variables in a presentation of the complex sector structure.

Place Figure18 About Here

Discussion and Conclusions

Criticism of the Department of Defense and the management of the weapon acquisition process in the literature and from those interviewed for this

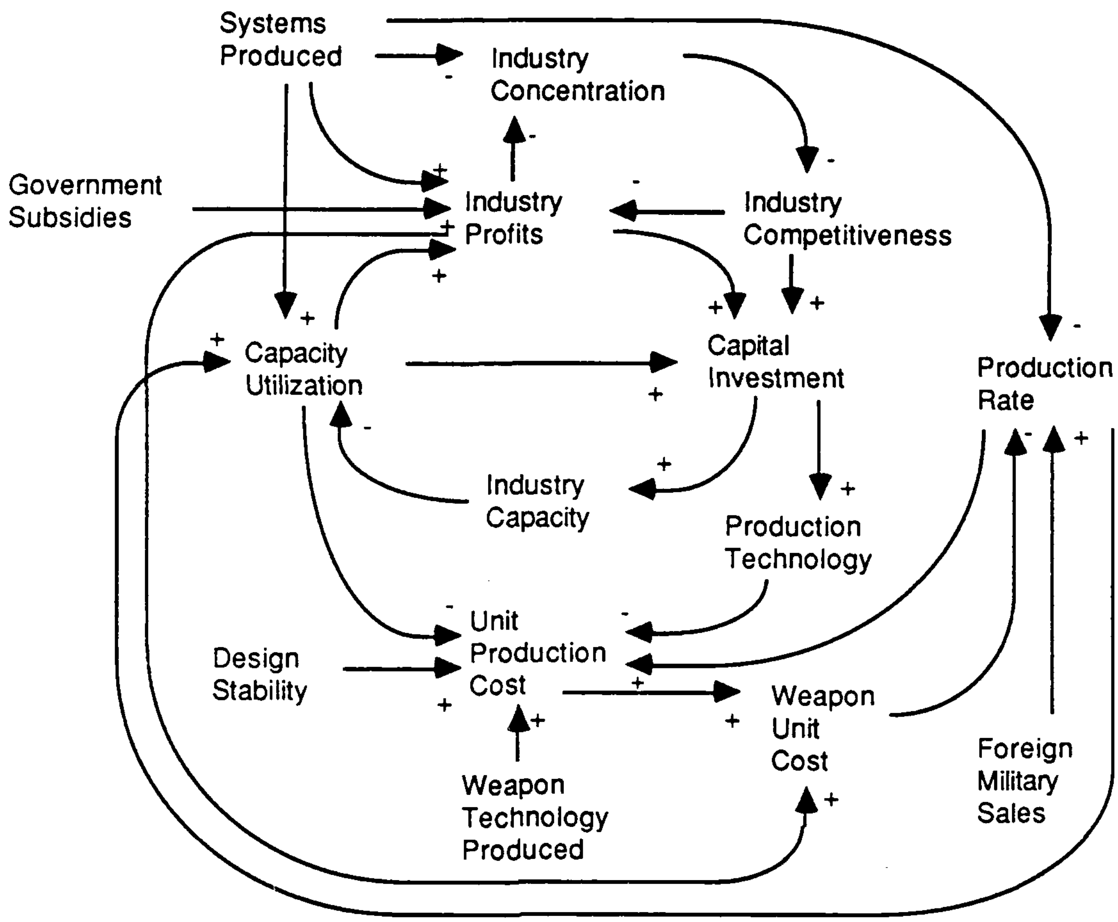


Figure 18. Industry Sector Complex Structure

research have emphasized five perceived structural flaws. They are: 1) the lack of joint service cooperation, coordination and planning (Fallows 1981, Luttwak 1984, President 1986, Stubbing 1986); 2) an emphasis on the development and acquisition of very expensive and overly complex weapon systems (Fallows 1981, Gansler 1980, Luttwak 1984, Stubbing 1986); 3) increasingly lengthy development and production phases for the weapons which are acquired (Coulam 1977, Fallows 1981, Gansler 1980, Stubbing 1986); 4) large and growing bureaucracies within the Department of Defense which contribute to the three problem areas above, and which advocate complex weapon systems without fully considering their operational necessity or the cost and operational effectiveness tradeoffs (Brown and Korb 1973, Fallows 1981, Gansler 1980, Luttwak 1984, Stubbing 1986); and 5) an increasingly complex legal environment in which the negotiations take place between the government and the contractors. This results in the acquisition process being more and more insulated from the threat and less insulated from Congressional micromanagement (Luttwak 1984, Kotz 1988, Stubbing 1986).

The interview discussions used as a primary source of information in conducting this research provided many differing opinions about these perceived structural flaws. The literature available in the area tends to be highly critical of the Department of Defense, and so the picture which results from a review of the literature alone is biased. While the interview respondents did not all agree on these five points, a majority did agree that past studies of the acquisition system have not taken the necessary step of identifying the complex, interrelated structural elements of the acquisition system. And further, the studies have not dealt with the perceived problems in a way that integrates all of the issues which bear on the problems. Past studies generally have investigated relatively micro-level issues or have

recommended relatively micro-level solutions. These studies and their recommendations have neglected the fact that complex problems cannot be effectively solved by implementing changes which are aimed at symptoms rather than real structural flaws.

Agreement among those interviewed also exists that the acquisition system seems to be over-regulated and is bogged down in a cumbersome "legal thicket." The evolving legal thicket seems to be the result of policy changes based on studies which have stressed simple solutions where there are none. As the model illustrates, the system is highly complex involving threat influences, national priorities, the acquisition and budgeting processes, and defense industry structure and conduct. The current laws and regulations which regulate the system are growing more restrictive and may preclude the possibility of managing the system more efficiently or more effectively.

Finally, the interview respondents agreed that a system framework which stresses macro structures and the interaction among the system's components could be a useful tool to aid in weapon acquisition policy analysis. A system framework such as the one described in this paper is only the first step in viewing system solutions.

Several of those interviewed stressed that the problem of rising weapon unit cost is based in the development of weapons requirements and the subsequent design of the weapons. Using the model presented here, a loop which involves several of the sector models can be traced. The requirements process is the dominant force in the interaction of the threat sector with the defense sector. The threat assessment which provides the basis for an operational requirement takes place in an environment where the accuracy of the assessment is strongly influenced by the effect of time. Because of the length of time that it now takes to develop and produce a weapon system, the

threat must be estimated farther and farther into the future, which by necessity results in a wider interval between estimation and what actually results. The natural reaction is to base the requirement on a conservative estimate of the threat, which in this case, is to project the highest capability. This is not necessarily due to a technological bias or a bureaucratic ploy as some have inferred, rather it is the safest and most conservative approach, which is necessitated by our growing weapons development period.

Once the requirement is set in the short term, the design process to develop a weapon system which can fill the requirement is begun. Because the requirement is based on a very sophisticated threat, and the design as a matter of policy must counter the threat with a technological superiority rather than a numerical advantage an extremely sophisticated design is produced. Some authors view this as "gold plating" while others view it simply as a conservative approach to the problem. The result is a highly sophisticated design which often employs new technologies with their inherent risk and typically high cost. Once the design is produced the tendency is for it to be adhered to regardless of updated intelligence information. That just seems to be the way the system works. This is not so different from any large organization which avoids change and radical decision-making shifts whenever possible.

The strict adherence to a design results in an inability to make quality for quantity tradeoffs once the design phase is completed and also precludes cost for performance tradeoffs as well. Depending on the weapon design and the state of the art in weapon technologies the tendency is for the development period to grow as a function of the intelligence estimate horizon. Unfortunately, as the development periods grows, it results in

longer times between initial weapon design and initial operational capability which require even longer intelligence estimation horizons. One can see the positive feedback loop that exists in the system. The system's structure explains the rising unit cost phenomena without resorting to interpreting Department of Defense actions as being politically motivated, institutionally inefficient, or anything else.

Viewing the problems with a limited or micro perspective can and has resulted in many different interpretations of the systems behavior. None of the arguments put forth, however, have been very convincing. The objective is to employ this model to provide a frame of reference for further policy discussions similar to the one just concluded. For example, given the system's structure, it may be a useful national policy to pursue technology for its own sake. Since intelligence estimates are inherently flawed simply let the United States' advisaries react to a technological push. The loop structure of the model shows that given some real technological advantages, such a policy would reduce system production time and resulting costs.

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